Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (Currently Amended): A method of obtaining overlay measurements for a semiconductor wafer, the method comprising:

forming a periodic grating on the wafer having:

a first set of gratings,

wherein the first set of gratings are formed on the wafer using a first mask, and

a second set of gratings,

wherein the second set of gratings are formed on the wafer using a second mask,

wherein the first and second sets of gratings are intended to be formed on the wafer with an intended asymmetrical alignment when the first mask and second mask are in alignment;

selecting a wavelength;

measuring a diffraction signal of the first and second sets of gratings after the first and second sets of gratings are formed on the wafer using the selected wavelength; and

determining a misalignment between the first and second sets of gratings formed on the wafer based on the measured diffraction signal.

Claim 2 (Original): The method of claim 1, wherein the measured diffraction signal is a zero-order diffraction.

Claim 3 (Original): The method of claim 2, wherein only the zero-order diffraction is measured.

Claim 4 (Original): The method of claim 1, wherein the diffraction signal is measured using an optical metrology system.

Claim 5 (Original): The method of claim 4, wherein the optical metrology system includes an ellipsometer.

Claim 6 (Original): The method of claim 4, wherein the optical metrology system includes a reflectometer.

Claim 7 (Original): The method of claim 1, wherein the diffraction signal is measured using an incident signal with a normal incidence angle.

Claim 8 (Original): The method of claim 1, wherein the diffraction signal is measured using an incident signal with an oblique incidence angle.

Claim 9 (Original): The method of claim 8, wherein the incident signal has an azimuthal angle of zero degrees.

Claim 10 (Original): The method of claim 8, wherein the incident signal has an azimuthal angle of about 45 degrees.

Claim 11 (Original): The method of claim 10, wherein measuring the diffraction signal includes:

measuring the amplitude of the diffraction signal.

Claim 12 (Original): The method of claim 1 further comprising:

generating a set of diffraction signals for a range of possible misalignments between the first and second sets of gratings,

wherein each diffraction signal in the set corresponds to a different possible misalignment within the range of possible misalignments.

Claim 13 (Original): The method of claim 12 further comprising:

generating a response curve of the correspondence between the different possible misalignments of the first and second sets of gratings and the set of diffraction signals.

Claim 14 (Currently Amended): The method of claim 13 ~~further comprising~~, wherein selecting a wavelength comprises:

generating a plurality of response curves using various wavelengths, polarizations, and/or incidence angles; and

selecting a desirable wavelength, polarization, and/or incidence angle based on the generated response curves.

Claim 15 (Original): The method of claim 12 further comprising:

determining the intended asymmetric alignment between the first and second sets of gratings based on the generated set of diffraction signals and range of possible alignments.

Claim 16 (Original): The method of claim 12, wherein the set of diffraction signals are generated empirically.

Claim 17 (Original): The method of claim 12, wherein the set of diffraction signals are generated using modeling.

Claim 18 (Original): The method of claim 12, wherein the determining the misalignment between the first and second sets of gratings comprises:

comparing the measured diffraction signal to the generated set of diffraction signals; and

determining the possible misalignment that corresponds to the diffraction signal from the generated set of diffraction signals that matches the measured diffraction signal.

Claim 19 (Original): The method of claim 1, wherein the periodic grating includes:

a first portion with the first and second sets of gratings having a first intended asymmetric alignment; and

a second portion with the first and second sets of gratings having a second intended asymmetric alignment,

wherein the first and second intended asymmetric alignments are opposite in direction.

Claim 20 (Original): The method of claim 19, wherein measuring a diffraction signal further comprises:

measuring a first diffraction signal from the first portion of the periodic grating; and

measuring a second diffraction signal from the second portion of the periodic grating.

Claim 21 (Original): The method of claim 20 further comprising:

computing a difference between the first and second diffraction signals.

Claim 22 (Original): The method of claim 20, wherein the periodic grating includes:

a third portion having only the first set of gratings; and

a fourth portion having only the second set of gratings.

Claim 23 (Original): The method of claim 22 further comprising:

obtaining the geometry of the first set of gratings in the third portion of the periodic grating; and

obtaining the geometry of the second set of gratings in the fourth portion of the periodic grating.

Claim 24 (Original): The method of claim 23, wherein the geometry of the first and second sets of gratings is obtained using an optical metrology system.

Claim 25 (Original): The method of claim 19 further comprising:

generating a set of diffraction signals for a range of possible misalignments between the first and second sets of gratings; and

generating a set of difference signals based on the generated set of diffraction signals,

wherein each difference signal in the set corresponds to the difference between two diffraction signals in the generated set of diffraction signals.

Claim 26 (Original): The method of claim 25 further comprising:

generating a calibration curve of the correspondence between the different possible alignments of the first and second sets of gratings and the set of difference signals.

Claim 27 (Original): The method of claim 25, wherein the determining the misalignment between the first and second sets of gratings comprises:

comparing the computed difference between the first and second difference signals to the generated set of difference signals; and

determining the possible misalignment that corresponds to the difference signal from the generated set of difference signals that matches the computed difference.

Claim 28 (Original): The method of claim 1,

wherein the first and second sets of gratings include a plurality of ridges that repeat at a periodic interval, and

wherein the ridges of the first and second sets of gratings alternate.

Claim 29 (Original): The method of claim 28,

wherein the ridges of the first and second sets of gratings include centerlines having a spacing between the centerlines of the ridges of the first and second sets of gratings, and

wherein the first and second sets of gratings are symmetrically aligned when the spacing between the centerlines is uniform and asymmetrically aligned when the spacing between the centerlines is non-uniform.

Claim 30 (Original): The method of claim 29, wherein the intended asymmetric alignment includes an offset from symmetrical alignment of the first and second sets of gratings.

Claim 31 (Original): The method of claim 30, wherein the offset is about a quarter of the periodic interval of the first and second sets of gratings.

Claim 32 (Original): The method of claim 1,

wherein the first and second sets of gratings include a plurality of ridges that repeat at a periodic interval, and

wherein the ridges of the second set of gratings are formed on the ridges of the first set of gratings.

Claim 33 (Original): The method of claim 32,

wherein the ridges of the first and second sets of gratings include centerlines, and

wherein the first and second sets of gratings are symmetrically aligned when the centerlines of the ridges of the first and second sets of gratings are aligned and asymmetrically aligned when the centerlines are not aligned.

Claim 34 (Original): The method of claim 33, wherein the intended asymmetric alignment includes an offset from symmetrical alignment of the first and second sets of gratings.

Claim 35 (Original): The method of claim 34, wherein the ridges of the second set of gratings includes a linewidth, and wherein the offset is about a quarter of the linewidth of the ridges of the second set of gratings.

Claim 36 (Original): The method of claim 1, wherein forming a periodic grating on the wafer comprises:

forming a periodic grating in a first metrology field on the wafer;

forming a periodic grating in a second metrology field on the wafer,

wherein the first and second metrology fields are separated by a distance on the wafer;

obtaining overlay measurements from the first and second metrology fields; and

computing a tilt error arc based on the obtained overlay measurements.

Claim 37 (Original): The method of claim 36, wherein the tilt error arc is computed as the difference between the overlay measurements divided by the distance between the first and second metrology fields.

Claim 38 (Currently Amended): A method of obtaining overlay measurements for a semiconductor wafer using a periodic grating, the method comprising:

forming a first set of gratings of the periodic grating on the wafer;

forming a second set of gratings of the periodic grating on the wafer,

wherein the first and second sets of gratings are formed using separate masks, and

wherein the second set of gratings are intended to be formed on the wafer with an intended asymmetrical alignment from the first set of gratings when the separate masks are in alignment;

generating a set of diffraction signals at a selected wavelength for a range of possible misalignments between the first and second sets of gratings,

wherein each of the diffraction signal in the generated set of diffraction signals corresponds to a possible misalignment between the first and second sets of gratings;

measuring a diffraction signal of the first and second sets of gratings after the first and second sets of gratings are formed on the wafer,

wherein the diffraction signal is measured using the selected wavelength; and

determining a misalignment between the first and second sets of gratings based on the measured diffraction signal and the generated set of diffraction signals.

Claim 39 (Original): The method of claim 38, wherein the determining the misalignment between the first and second sets of gratings comprises:

comparing the measured diffraction signal to the generated set of diffraction signals; and

determining the possible misalignment that corresponds to the diffraction signal from the generated set of diffraction signals that matches the measured diffraction signal.

Claim 40 (Original): The method of claim 39 further comprising:

determining a misalignment between the first and second masks based on the determined misalignment between the first and second sets of gratings.

Claim 41 (Original): The method of claim 40, wherein the amount and direction of misalignment of the first and second masks corresponds to the amount and direction of misalignment of the first and second sets of gratings.

Claim 42 (Original): The method of claim 38, wherein the intended asymmetric alignment between the first and second sets of gratings is selected based on the generated set of diffraction signals and range of possible misalignments.

Claim 43 (Original): The method of claim 38, wherein the measured diffraction signal is a zero-order diffraction.

Claim 44 (Original): The method of claim 38 further comprising:

generating a plurality of sets of diffraction signals at various wavelengths, polarizations, and/or incidence angles.

Claim 45 (Original): The method of claim 44 further comprising:

selecting a desirable wavelength, polarization, and/or incidence angle based on the generated sets of diffraction signals.

Claim 46 (Original): The method of claim 38, wherein forming a first set of gratings and forming a second set of gratings comprise:

forming a first portion of the periodic grating having the first and second sets of gratings at a first intended asymmetric alignment;

forming a second portion of the periodic grating having the first and second sets of gratings at a second intended asymmetric alignment,

wherein the first and second intended asymmetric alignments are opposite in direction.

Claim 47 (Original): The method of claim 46, wherein measuring a diffraction signal further comprises:

measuring a first diffraction signal from the first portion of the periodic grating;

measuring a second diffraction signal from the second portion of the periodic grating; and

computing a difference signal based on the difference between the measured first and second diffraction signals.

Claim 48 (Original): The method of claim 47 further comprising:

generating a set of difference signals based on the generated set of diffraction signals;

comparing the computed difference signal to the generated set of difference signals; and

determining the alignment that corresponds to the difference signal from the generated set of difference signals that matches the computed difference signal.

Claim 49 (Original): The method of claim 48 further comprising:

forming a third portion of the period grating having only the first set of gratings; and

forming a fourth portion of the periodic grating having only the second set of gratings.;

obtaining the geometry of the first set of gratings in the third portion of the periodic grating; and

obtaining the geometry of the second set of gratings in the fourth portion of the periodic grating.

Claim 50 (Original): The method of claim 48, wherein the generated set of diffraction signals are generated based on the obtained geometry of the first and second sets of gratings.

Claim 51 (Original): The method of claim 48, wherein obtaining the geometry of the first set of gratings and the second set of gratings comprises:

comparing the measured diffraction signals to a library of simulated-diffraction signals, each simulated-diffraction signal having an associated theoretical geometry.

Claim 52 (Original): The method of claim 38,

wherein the first and second sets of gratings include a plurality of ridges that alternate with a spacing between the ridges,

wherein the first and second sets of gratings are symmetrically aligned when the spacing between the ridges of the first and second sets of gratings is uniform and asymmetrically aligned when the spacing is non-uniform.

Claim 53 (Original): The method of claim 38,

wherein the first and second sets of gratings include a plurality of ridges with centerlines,

wherein the ridges of the second set of gratings are formed on the ridges of the first set of gratings, and

wherein the first and second sets of gratings are symmetrically aligned when the centerlines of the ridges of the first and second sets of gratings are aligned and asymmetrically aligned when the centerlines are not aligned.

Claim 54 (Original): The method of claim 38 further comprising:

forming a periodic grating in a first metrology field on the wafer;

forming a periodic grating in a second metrology field on the wafer separated by a distance from the first metrology field;

obtaining overlay measurements from the first and second metrology fields; and

determining a tilt error arc by dividing the difference between the overlay measurements by the distance between the first and second metrology fields.

Claim 55 (Currently Amended): A method of obtaining overlay measurements for a semiconductor wafer using a periodic grating formed on the wafer, the method comprising:

obtaining the wafer, wherein the period grating on the wafer comprises:

a first set of grating that were formed on the wafer using a first mask,

a second set of gratings that were formed on the wafer using a second mask,

wherein the first and second sets of gratings ~~that~~ were intended to be formed on the wafer with an asymmetric alignment when the first mask and second mask are in alignment;

generating a set of diffraction signals at a selected wavelength for a plurality of possible misalignments between the first and second sets of gratings;

measuring a diffraction signal of the first and second sets of gratings from the obtained wafer,

wherein the diffraction signal is measured using the selected wavelength, and

wherein the measured diffraction signal is a zero-order diffraction;

comparing the measured diffraction signal to the generated set of diffraction signals; and

determining an amount and direction of misalignment between the first and second sets of gratings on the obtained wafer based on the possible alignment that corresponds to the diffraction signal from the set of diffraction signals that matches the measured diffraction signal.

Claim 56 (Original): The method of claim 55 further comprising:

determining an amount and direction of misalignment between the first and second masks based on the determined amount and direction of misalignment between the first and second sets of gratings.

Claim 57 (Original): The method of claim 55,

wherein the periodic grating on the wafer further comprises:

a first periodic grating oriented for obtaining overlay measurements in a first coordinate direction, and

a second periodic grating oriented for obtaining overlay measurements in a second coordinate direction; and

wherein measuring a diffraction signal further comprises:

measuring a first diffraction signal from the first periodic grating, and

measuring a second diffraction signal from the second periodic grating without rotating the wafer.

Claim 58 (Original): The method of claim 57, wherein the measured diffraction signals and the generated diffraction signals have amplitude ratios, and wherein the amplitude ratios of the measured diffraction signals are compared with the amplitude ratios of the generated diffraction signals.

Claim 59 (Original): The method of claim 57, wherein the first periodic grating comprises a plurality of ridges oriented at about 45 degrees, and wherein the second periodic grating is a mirror-image of the first periodic grating.

Claim 60 (Original): The method of claim 57, wherein the diffraction signals are measured using an oblique and conical incident signal.

Claim 61 (Original): The method of claim 57, wherein the diffraction signals are measured using an incident signal with an azimuthal angle of about 45 degrees.

Claim 62 (Original): The method of claim 55, wherein the diffraction signal is measured using a normal incidence angle.

Claim 63 (Original): The method of claim 55, wherein the diffraction signal is measured using an oblique incidence angle with an azimuthal angle of zero degrees.

Claim 64 (Original): The method of 55, wherein the periodic grating comprises:

a first portion with the first and second sets of grating having a first asymmetric alignment; and

a second portion with the first and second sets of grating having a second asymmetric alignment,

wherein the first and second asymmetric alignments are opposite in direction.

Claim 65 (Original): The method of claim 64, wherein measuring a diffraction signal further comprises:

generating differences between pairs of diffraction signals from the generated set of diffraction signals,

wherein a pair of diffraction signals for each generated difference correspond to two different possible misalignments of the first and second sets of gratings;

measuring a first diffraction signal from the first portion of the periodic grating;

measuring a second diffraction signal from the second portion of the periodic grating;

computing a difference between the measured first and second diffraction signals; and

comparing the computed difference with the generated differences.

Claim 66 (Original): The method of claim 64,

wherein the periodic grating further comprises:

a third portion having only the first set of gratings, and

a fourth portion having only the second set of gratings;

obtaining the geometry of the first set of gratings in the third portion of the periodic grating; and

obtaining the geometry of the second set of gratings in the fourth portion of the periodic grating,

wherein the geometry of the first set of gratings and the second set of gratings are obtained by comparing the measured diffraction signals to a library of simulated-diffraction signals, each simulated-diffraction signal having an associated theoretical geometry.

Claim 67 (Original): The method of claim 55 further comprising:

a first metrology field on the wafer;

a second metrology field on the wafer separated by a distance from the first metrology field;

obtaining overlay measurements from the first and second metrology fields; and

determining a tilt error arc by dividing the difference between the overlay measurements by the distance between the first and second metrology fields.

Claim 68 (Original): The method of claim 55,

wherein the first and second sets of gratings include a plurality of ridges that alternate with a spacing between the ridges,

wherein the first and second sets of gratings are symmetrically aligned when the spacing between the ridges of the first and second sets of gratings is uniform and asymmetrically aligned when the spacing is non-uniform.

Claim 69 (Original): The method of claim 55,

wherein the first and second sets of gratings include a plurality of ridges with centerlines,

wherein the ridges of the second set of gratings are formed on the ridges of the first set of gratings, and

wherein the first and second sets of gratings are symmetrically aligned when the centerlines of the ridges of the first and second sets of gratings are aligned and asymmetrically aligned when the centerlines are not aligned.

Claim 70 (Currently Amended): A system to obtain overlay measurements of a semiconductor wafer, the system comprising:

a periodic grating formed on the wafer comprising:

a first set of gratings formed using a first mask,

a second set of gratings formed using a second mask, and

wherein the first and second sets of gratings are <u>intended to be</u> formed with an asymmetric alignment <u>when the first mask and second mask are in alignment</u>; and

an optical metrology system comprising:

a detector configured to measure a diffraction signal from the first and second sets of gratings <u>using a selected wavelength</u>, and

a signal processing unit configured to determine a misalignment between the first and second sets of gratings based on the measured diffraction signal.

Claim 71 (Original): The system of claim 70, wherein the signal processing unit is configured to compare the measured diffraction signal to a set of diffraction signals generated for a plurality of possible alignments between the first and second sets of gratings.

Claim 72 (Original): The system of claim 70, wherein the periodic grating further comprises:

a first periodic grating oriented in a first coordinate direction; and

a second periodic grating oriented in a second coordinate direction,

wherein overlay measurements can be obtained in the first and second coordinate directions using the first and second periodic gratings without rotating the wafer.

Claim 73 (Original): The system of claim 72, wherein the first periodic grating comprises a plurality of ridges oriented at about 45 degrees, and wherein the second periodic grating is a mirror-image of the first periodic grating.

Claim 74 (Original): The system of claim 72, wherein the optical metrology system comprises:

a source configured to produce an oblique and conical incident signal.

Claim 75 (Original): The system of claim 70, wherein the optical metrology system comprises:

a source configured to produce a normal incident signal.

Claim 76 (Original): The system of claim 70, wherein the optical metrology system comprises:

a source configured to produce an incident signal having an oblique incidence angle and an azimuthal angle of zero degrees.

Claim 77 (Original): The system of claim 70, wherein the periodic grating comprises:

a first portion with the first and second sets of gratings having a first asymmetric alignment; and

a second portion with the first and second sets of gratings having a second asymmetric alignment.

Claim 78 (Original): The system of claim 77,

wherein the detector is configured to measure a first diffraction signal from the first portion of the period grating and a second diffraction signal from the second portion of the periodic grating, and

wherein the signal processor is configured to determine the amount and direction of misalignment between the first and second masks used to form the first and second sets of gratings based on the measured first and second diffraction signals.

Claim 79 (Original): The system of claim 78, wherein the signal processor is configured to determine the alignment of the first and second sets of gratings by comparing the difference between the measured first and second diffraction signals to a set of difference signals generated for a plurality of possible misalignments between the first and second sets of gratings.

Claim 80 (Original): The system of claim 78, wherein the periodic grating further comprises:

a third portion having only the first set of gratings; and

a fourth portion having only the second set of gratings.

Claim 81 (Original): The system of claim 80, wherein the optical metrology system comprises:

a library of simulated-diffraction signals having a set of theoretical geometry of the first and second sets of gratings;

wherein the detector is configured to measure a diffraction signal from the third portion and a diffraction signal from the fourth portion; and

wherein the signal processing unit is configured to compare the measured diffraction signal to the simulated-diffraction signals to determine the geometry of the first and second sets of gratings.

Claim 82 (Original): The system of claim 70 further comprising:

a first metrology field on the wafer;

a second metrology field on the wafer separated by a distance from the first metrology field;

wherein the optical metrology system is configured to obtain overlay measurements from the first and second metrology fields and determine a tilt error arc by dividing the difference between the overlay measurements by the distance between the first and second metrology fields.

Claim 83 (Original): The system of claim 70, wherein the first and second sets of gratings include a plurality of ridges that alternate with a spacing between the ridges; and wherein the first and second sets of gratings are symmetrically aligned when the spacing between the ridges of the first and second sets of gratings is uniform and asymmetrically aligned when the spacing is non-uniform.

Claim 84 (Original): The system of claim 70, wherein the first and second sets of gratings include a plurality of ridges with centerlines; wherein the ridges of the second set of gratings are formed on the ridges of the first set of gratings; and wherein the first and second sets of gratings are symmetrically aligned when the centerlines of the ridges of the first and second sets of gratings are aligned and asymmetrically aligned when the centerlines are not aligned.

Claim 85 (Currently Amended): A computer-readable storage medium containing computer executable instructions for causing a computer to obtain overlay measurements for a semiconductor wafer, comprising instructions for:

measuring a diffraction signal <u>at a selected wavelength</u> of a first set of grating and a second set of gratings of a periodic grating formed on the wafer, wherein

the first set of gratings were formed using a first mask,

the second set of gratings were formed using a second mask, and

wherein the first and second sets of gratings were <u>intended to be</u> formed on the wafer with an asymmetric alignment <u>when the first mask and second mask are in alignment</u>;

generating a set of diffraction signals <u>at the selected wavelength</u> for a plurality of possible misalignments between the first and second sets of gratings;

determining a misalignment of the first and second sets of gratings formed on the wafer based on the measured diffraction signal and the generated set of diffraction signals; and

determining the amount and direction of misalignment between the first and second masks based on the determined misalignment of the first and second sets of gratings formed on the wafer.

Claim 86 (Original): The computer-readable storage medium of claim 85, further comprising instructions for:

generating differences between pairs of diffraction signals from the generated set of diffraction signals,

wherein a pair of diffraction signals for each generated difference corresponds to two different possible misalignments of the first and second sets of gratings;

measuring a first diffraction signal from a first portion of the periodic grating,

wherein the first and second sets of gratings in the first portion have a first asymmetric alignment;

measuring a second diffraction signal from a second portion of the periodic grating,

wherein the first and second sets of gratings in the second portion have a second asymmetric alignment;

computing a difference between the measured first and second diffraction signals; and

comparing the computed difference with the generated differences.

Claim 87 (Original): The computer-readable storage medium of claim 85, further comprising instructions for:

obtaining the geometry of the first set of gratings; and

obtaining the geometry of the second set of gratings,

wherein the generated set of diffraction signals is generated based on the obtained geometry of the first and second sets of gratings.

Claim 88 (Original): The computer-readable storage medium of claim 87, further comprising instructions for:

measuring diffraction signals of the first set of gratings;

measuring diffraction signals of the second set of gratings; and

comparing the measured diffraction signals to a library of simulated-diffraction signals having a set of theoretical geometry of the first and second sets of gratings.

Claim 89 (Original): The computer-readable storage medium of claim 88, wherein the diffraction signals of the first set of gratings are measured from a third portion of the grating having only the first set of gratings, and the diffraction signals of the second set of gratings are measured from a fourth portion of the grating having only the second set of gratings.

Claim 90 (Original): The computer-readable storage medium of claim 85, further comprising instructions for:

obtaining overlay measurements from a first metrology field on the wafer;

obtaining overlay measurements from a second metrology field on the wafer, wherein the first and second metrology fields are separated by a distance; and

determining a tilt error arc by dividing the difference in the obtained overlay measurements from the first and second metrology fields by the distance between the first and second metrology fields.

Claim 91 (Original): The computer-readable storage medium of claim 85, further comprising instructions for:

measuring a first diffraction signal from a first periodic grating;

determining the amount and direction of misalignment between the first and second mask in a first coordinate direction using the first measured diffraction signal;

measuring a second diffraction signal from a second periodic grating without rotating the wafer; and

determining the amount and direction of misalignment between the first and second mask in a second coordinate direction using the second measured diffraction signal.